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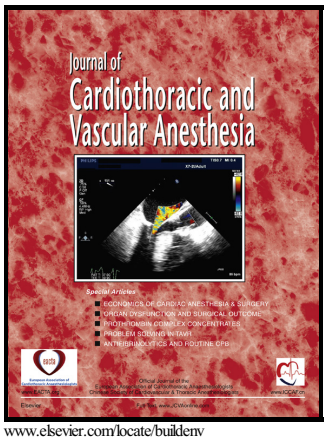

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When cardiopulmonary bypass is not an option- a case of massive retrosternal goiter with severe tracheal compression in an extremely obese patient

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Recent literature has highlighted the successful use of extracorporeal membrane oxygenation (ECMO) in severe airway obstruction due to mediastinal mass when all other conventional management options have failed[1-2]. However, this case report of a massive retrosternal goiter highlights that mechanical circulatory support (i.e. ECMO or cardiopulmonary bypass) may not be possible in all cases of severe airway obstruction. We describe an approach to mediastinal masses which mitigates the risk of airway loss and cardiovascular collapse- a crucial objective for cases where cardiopulmonary bypass is not a viable rescue option. Written patient consent for publication of this case was obtained.

Case Report

A 32 year old female was booked for a thyroidectomy and sternotomy for a massive retrosternal goiter (RSG) causing progressive airway obstruction. Symptoms included stridor, dyspnea and severe orthopnea that necessitated sleeping upright to avoid precipitation of acute respiratory distress. She was extremely obese with a weight of 212kg, height of 175cm and BMI 69kg/m^2.

Computed tomography (CT) scan demonstrated that the size, position and dumbbell shape of the goiter caused a significant mass effect in the mediastinum. Anterior mediastinal extension of the goiter to the right atrium resulted in almost complete obstruction of the superior vena cava (SVC) and posterior displacement of the aortic arch. Severe tracheal compression extended from the level of the thoracic inlet to just above the carina, causing the lumen to be bifurcated at its narrowest point (Figure 1).

Pre-induction access for cardiopulmonary bypass (CPB) was requested due to the high potential risk of airway loss and/or cardiovascular collapse post-induction of general anesthesia combined with limited options for rescue, however this was declined by the cardiothoracic surgeons. The patient was deemed unsuitable for CPB due to (i) the inability of a perfusion circuit to generate adequate flows to match the cardiac output of an extremely obese patient, (ii) the anticipated difficulty obtaining vascular groin access due to her body habitus and (iii) the requirement to establish vascular access in a supine position which she was unable to tolerate.

Without CPB as an option, a staged induction was performed. Intravenous access was obtained in both lower limbs and an arterial line was inserted. An awake fiberoptic intubation (AFOI) was performed with the patient in a sitting position. A remifentanil target-controlled infusion was used for conscious sedation and 2% lignocaine (nebulized and gargled) was used to topicalize the airway. An oral fiberoptic intubation was successful despite encountering significant resistance during passage of a size 7.0 NIM^{TM} EMG tracheal tube (Figure 2). The NIM tube was customized to allow placement of the cuff below the distal tracheal obstruction with the electrodes still positioned at the vocal cords. Customization of the NIM tube was achieved by removing and reapplying the electrodes more proximally to match the distance from the tube tip when positioned just above the carina to the vocal cords using measurements from the CT scan [3]. Correct positioning of the tube tip and the electrodes were confirmed with a bronchoscope and videolaryngoscope, respectively.

General anesthesia was induced using an upwardly titrated target-controlled infusion (TCI) of propofol, while spontaneous respiration was maintained. The propofol TCI plasma-target commenced at 2mcg/mL and increased by 1mcg/mL increments using a previously described SponTaneous Respiration using IntraVEnous anesthesia (STRIVE) protocol[4]. After loss of consciousness, at an effect site of 5mcg/mL, the patient was sequentially transitioned to positive pressure ventilation, positioned supine and then administered neuromuscular blockade. At each stage, the patients hemodynamics were closely observed, however they remained stable throughout the induction process.

The subsequent anesthesia and surgery involving a median sternotomy proceeded uneventfully with a multinodular goiter weighing 720g excised. The patient was successfully extubated in the intensive care unit the next day and discharged home 5 days later.

Discussion

The anesthetic management for massive retrosternal goiter is controversial. Traditional teaching describes the potential for difficult airway management (and even cardiovascular compromise), during the induction of general anesthesia[5], however recent evidence suggests that this may be unfounded[6-7]. Expert opinion is often divided, with some even recommending the use of CPB in cases of extreme tracheal compression[8].

In the event that airway loss or cardiovascular collapse occurs due to mediastinal mass compression, management traditionally involves measures to alleviate mass effect (repositioning of the patient, rigid bronchoscopy and urgent sternotomy) and/or establishing CPB[5,9]. The role of CPB in the management of massive retrosternal goiter is

unclear, as most RSGs are not considered to be true mediastinal masses[6]. There are several reported cases where CPB access was electively established pre-operatively for RSGs[10-12], however the hemodynamics in all of these cases remained stable and CPB was not required.

We believed that the degree of tracheal compression and extreme obesity would compromise our ability to intubate and oxygenate our patient during a conventional i.v. induction. Although a fiberoptic guided intubation is usually successful during extrinsic tracheal compression caused by massive RSG, our main concerns related to the potential for impossible ventilation and/or cardiovascular collapse subsequent to this. The symptoms, size and location of the RSG demonstrated that there was a significant mediastinal mass effect, which was complicated by the extreme obesity and warranted consideration of CPB. Our specific concerns related to the potential for: (i) difficult or impossible positive pressure which could generate high intrathoracic pressure and precipitate cardiovascular collapse (ii) precipitous oxygen desaturation in the event of failed airway management and (iii) extremely limited rescue options in the event of a failed airway or cardiovascular collapse.

As the non-cardiac anesthetists involved in this case, we did not expect that the cardiothoracic surgeons would decline CPB and it was interesting to discover the limitations that may preclude a patient from receiving CPB (in particular extreme obesity).

To safely commence CPB the perfusion circuit must be able to match the patient's cardiac output demands. The calculated cardiac output for our patient was 7.7L/min (using the Mosteller formula). Perfusion circuits at our institution at that time were limited to 6.5L/min. Whether this would definitively rule out CPB in an extremely obese patient is debatable. Case reports exist of successful bypass on extremely obese patients[14-15] and a perfusion circuit capable of flows greater than 8L/min could have been sourced. These

patients may also tolerate flows lower than their calculated cardiac output to maintain perfusion to essential organs (particularly with cooling). Regardless of the flows that would be required in an extremely obese patient, a perfusion circuit would be operating near maximal capacity which would be a highly challenging task.

Obtaining adequate access is another major issue when faced with a mediastinal mass and extreme obesity. To establish VA ECMO (veno-arterial extracorporeal membrane oxygenation) or CPB to support both airway loss and cardiovascular collapse, the inferior vena cava (via femoral vein), femoral artery and possibly superior vena cava need to be cannulated. To successfully cannulate these vessels (via the neck and groins) the patient should be ideally positioned supine, which would have been unachievable for our case. The body habitus of a morbidly obese patient would increase the difficulty obtaining groin access. Furthermore, cannulae of sufficient size need to be inserted to enable maximal flows from the perfusion circuit. A patient's vessels may not be large enough to accommodate the required size cannulae size, however this could be assessed with imaging (i.e. CT angiogram).

A patient on bypass also requires anticoagulation, however an increased bleeding tendency could significantly interfere with the surgical field of a thyroidectomy and increase the risk of damaging surrounding structures (including the recurrent laryngeal nerve). Other risks of bypass to generally consider include vascular injury, sepsis, embolism, renal failure and neurologic injury[15].

Whilst there was no single factor that definitively ruled out CPB in our patient, it was the combination of the above issues that prompted our cardiothoracic surgeons to declare her unsuitable for CPB. This essentially limited our rescue options to rigid bronchoscopy or

urgent sternotomy, which would also be potentially difficult. Faced with a high potential for airway loss, difficult ventilation and/or cardiovascular collapse, we implemented a staged induction described by Ng and Hartigan[16], which focused on preserving spontaneous ventilation. Firstly, the airway was secured with an awake fiberoptic intubation which provided several advantages: (i) it allowed the patient to remain upright maximizing comfort and airway patency (ii) oxygenation was maintained by spontaneous respiration (iii) an accurate assessment of the level and severity of tracheal obstruction could be made (including confirmation there was adequate distance beyond the obstruction) prior to inserting the tracheal tube and (iv) precise positioning of the tracheal tube in the distal trachea was possible (i.e. cuff below the obstruction with the tip above the carina).

After successful intubation, the induction focused on achieving stable hemodynamics during positive pressure ventilation in a supine position. The STRIVE method of propofol titration was used to induce general anesthesia because of its previous success to maintain spontaneous ventilation and hemodynamic stability in cases of airway obstruction[4]. Transitioning the patient from spontaneous respiration to positive pressure ventilation followed by supine positioning in a staged approach gave us the potential option of returning to a previous point of safety if hemodynamic instability did occur.

We believe the induction described in our case report was the safest possible method in managing this case. It should be noted that thorough assessment, preparation, multidisciplinary discussion and outlining of available and unavailable back-up plans were key components to optimize this patient's peri-operative outcome. Both ENT and cardiothoracic surgeons were also present throughout the induction in case rescue with rigid bronchoscopy or urgent sternotomy was required. Despite our concerns and request

for CPB, this case demonstrated that stable hemodynamics were achievable during positive pressure ventilation in the supine position in a patient with a massive RSG complicated by extreme obesity. Although recent studies of massive RSGs[6-7] may conclude that these goiters can be managed safely with a standard induction technique, there are still severe and/or complicated cases where advanced airway management techniques (including ECMO) should be advocated. ECMO may be the ultimate airway solution but it also has limitations, which may require alternative strategies.

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Figure legends

Figure 1- CT scan of patient- a) coronal section with arrows marking (X) extrathoracic and (Y) intrathoracic portions of the thyroid gland b) transverse section demonstrating tracheal compression at its narrowest

Figure 2- a) Video bronchoscopy image of trachea demonstrating severe tracheal compression above the carina (this corresponds to the section shown in Figure 1b)